A Bayesian Methodology for the Interval Estimation of the National Accounts of the Philippines

John Lourenze S. Poquiz[1*] and Shirlee R. Ocampo[2]
[1]Macroeconomic Accounts Service, Philippine Statistics Authority
[2]Mathematics Department, De La Salle University
*jls.poquiz@hotmail.com

Abstract: This paper aims to suggest an alternative method for the interval estimation of the Quarterly National Accounts of the Philippines. The Gross Domestic Product (GDP) is perhaps the most closely monitored measure of economic performance. While point estimates of the GDP growth is important, one could argue that interval estimates of the said economic indicator deserve more attention. GDP estimates, like most official statistics, is subject to revision—a result of measurement errors and the incompleteness of data during the initial estimation. Revisions highlight the uncertainty about the accuracy of the initial estimates. If the preliminary estimate would be revised in the future, how likely is it that the decisions made based from the preliminary estimates would not be far off from the decisions to be made based on the revised estimate? Interval estimation resolves this by reflecting a degree of uncertainty around the preliminary point estimate and indicate a range where the true value of the GDP growth could be located. At present, the Philippine Statistics Authority (PSA) publishes interval estimates of real GDP growth rates alongside the point estimate of the GDP growth. The confidence interval is computed using the methodology proposed by the paper of Virola and Parcon (1996). A study by Poquiz, Moscoso, and Guiam (2016) found that the interval estimates published by the PSA failed to capture the final estimate of GDP growth majority of the time. Both studies assumed that the final estimate of the GDP growth is its true value. Poquiz, Moscoso, and Guiam (2016) concludes that the interval estimates produced by the PSA failed to serve its purpose. This paper explores the use of Bayesian Inference in generating interval estimates for GDP growth. The final estimate of GDP growth was expressed as a linear function of the preliminary GDP growth estimate. Credible intervals were then generated for the regression parameters and predictions from the resulting models served as the upper and lower limits of the GDP growth. The results show the intervals generated by the Bayesian approach was considerably better in terms of capturing the final value of GDP growth compared to the intervals generated from the methodology of the PSA.

Keywords: Bayesian, Credible Intervals, National Accounts, GDP

1. INTRODUCTION

The Gross Domestic Product (GDP) is prerhaps the most closely monitored economic indicator. It is often considered as the prime measure of economic performance. Economist, policy makers, businessmen, and the academe are mostly interested in the growth of GDP, as it indicates how much the economy has improved from one period to another. The Philippine Statistics Authority releases the estimate of the GDP growth 55 days (before 2016, the time lag was 60 days) after the reference quarter. The first release of the GDP growth is preliminary and is subject to multiple rounds of revision. The preliminary GDP growth rate is first revised the following quarter. The revised estimate would again be revised every May, when the statistics agency revises the three-year series of the national accounts, taking into account the availability of new data. In effect, the preliminary estimate would undergo four rounds of revisions: once in the quarter following the release of the preliminary estimate and three times during the succeeding May estimation rounds. The revision policy for the National Accounts of the Philippines was based from the National Statistical Coordination Board (NSCB) Resolution No. 8 series of 1997. For the purposes of this study, we would consider that GDP growth that would no longer be subject to revision as final.

Considering the certainty that the preliminary estimate of GDP growth would change as new data becomes available, it is imperative for the statistics agency to release interval estimates of the GDP growth. The interval should indicate the range that would contain that final estimate of the GDP growth rates. The intervals would also be indicative of the *real* growth of GDP. Since preliminary releases are estimates based on incomplete information, intervals would be helpful tools to reflect the degree of uncertainty surrounding the estimates.

This paper aims to suggest alternative methods of interval estimation for the Quarterly National Accounts. The confidence interval is computed using the methodology proposed by the paper of Virola and Parcon (1996). A study by Poquiz, Moscoso, and Guiam (2016) found that the interval estimates published by the PSA failed to capture the final estimate of GDP growth majority of the time. Both studies assumed that the final estimate of the GDP growth is its true value. Poquiz, Moscoso, and Guiam (2016) concludes that the interval estimates produced by the PSA failed to serve its purpose. This paper explores the use of Bayesian Inference in generating interval estimates for GDP growth. The final estimate of GDP growth was expressed as a linear function of the preliminary GDP growth estimate. Credible intervals were then generated for the regression parameters and predictions from the resulting models served as the upper and lower limits of the GDP growth.

This paper explores a methodology of interval estimation using multiple approaches the classical ordinary least squares and a Bayesian approach, where priors would be determined for a scaling parameter that would determine the interval. The Bayesian method would then be compared with the results of the interval created using both the methodology utilized by the PSA and the intervals created using the classical linear regression. For all intervals generated, the parameters would be a function of the revisions in the National Accounts.

A Bayesian approach to interval estimation has some advantages. Confidence intervals do not have a straight-forward probabilistic interpretation that Bayesian credible intervals do. Second, the Bayesian approach allows statisticians the use of prior knowledge about the model parameter in the process of estimation.

The paper would have two parts: first would be a descriptive analysis of the revisions in the GDP growth rates since all the intervals would be functions of the revisions. The second part of the paper would be the generation of interval estimates of GDP growth rates.

2. METHODOLOGY

The objective of this paper is to propose a methodology for interval estimation of GDP growth rates. The estimation of the National Accounts requires data from many sources, making it very difficult to derive its variance analytically. There are usually two considerations in interval estimation: 1) the interval must contain the "true" parameter or prediction that needs to be estimated, and 2) the interval has to be short enough to be useful. We utilize two general methodologies for this study.

The intervals generated by the methodologies below would be compared with the intervals generated by the PSA. The PSA methodology would not be discussed in detail in this paper. Readers would instead be directed to Virola and Parcon (1996) and Poquiz, Moscoso, and Guiam (2016) for the details of the methodology.

2.1 Classical Linear Regression

The method follows the same general principle as the methodology currently being employed by the PSA. However, instead of using the average ratio between the initial and final GDP growth as a scaling factor for the initial GDP growth estimate, regression parameters were used. The ordinary least squares method was utilized having the final GDP growth as the endogenous variable and the initial GDP growth estimate would be exogenous.

$$GDP_{ft} = \beta_0 + \beta_1 GDP_{it} + \hat{u}_t \tag{1}$$

where GDP_{ft} is the final estimate at time t of the GDP growth rate, GDP_{it} is the initial GDP growth rate estimate and $\hat{u}t$ is the stochastic error terms which is assumed to be normally distributed with a constant variance. The parameters for the regression were the scaling factor and a confidence interval was generated for the parameters of the regression:

$$\{\widehat{\beta_{iU}} = \beta_i + z_{\frac{\alpha}{2}} * SE;\ \widehat{\beta_{iL}} = \beta_i - z_{\frac{\alpha}{2}} * SE\} \tag{2}$$

where SE is the standard error of the coefficients. The predictions intervals were based on the upper and lower limits of the regression parameters. The intervals were calculated using the expression below:

$$\{\widehat{GDP_{Ut}} = \widehat{\beta_{0U}} + \widehat{\beta_{1U}} * GDP_{it};\ \widehat{GDP_{Lt}} = \widehat{\beta_{0L}} + \widehat{\beta_{1L}} * GDP_{it}\} \tag{3}$$

2.2 Bayesian Analysis

Intervals using Bayesian Analysis would computed and compared against the intervals created using the approach of the PSA and the classical regression approach. In this method, the scaling parameters βi would be estimated as the mean of the posterior distribution. A credible interval would be created around the scaling factor, and the upper and lower limit of the GDP growth would be derived using the upper and lower limit of the interval of the scaling factor.

Generally, a Gaussian density is assigned for the likelihood function for Bayesian Regression Analysis, such that | X, β, σ ~ N(Xβ, σ^2I), assuming that the error terms are homoscedastic and serially uncorrelated, such that, ε ~ N(0, σ^2I). Our Bayesian linear model would have three parameters: the two regression coefficients and the variance. We would need to identify prior densities for these model parameters.

One of the most common approach in Bayesian Analysis is the use of noninformative priors. This would allow information from the data to dominate the posterior distribution. For this paper, we assign Jeffrey's Noninformative Prior for the variance. We can write our model as follows,

$$GDP_{ft} \sim N(X\beta, \sigma^2) \quad (4)$$

$$(X\beta, \sigma^2) \sim \frac{1}{\sigma^2} \quad (5)$$

Another popular approach in Bayesian is the use of conjugate priors. The natural conjugate prior for Bayesian linear models is the normal inverted-gamma prior [3]. For this specification, a flat prior would be assigned for the regression coefficients and an inverse gamma(α,β) distribution would be set as prior for variance. As a result, posterior inferences are sensitive to the hyper parameters α, β, which are usually set at low values. For this paper, the values for the hyper parameters would be set at (0.1,0.1).

Lastly, we utilize the uniform distribution as prior for the regression coefficients. This would ensure that all possible values for the regression coefficients would have equal probabilities.

$$\beta \sim \text{Uniform}(a, b) \quad (6)$$

The parameters of the model would be bound the hyperparameters a and b, which would could be set as the historical maximum and minimum magnitude of revisions. The variance would be assigned a flat prior. The resulting posterior distribution, however, would likely be improper since there is no know conjugacy between a normal likelihood and uniform prior.

3. REVISIONS OF THE NATIONAL ACCOUNTS

Similar to the methodology being utilized by the PSA to generate interval estimates of GDP growth, the intervals to be generated by this exercise are functions of revisions. Before we could generate intervals, we must first understand the nature of revisions in GDP growth.

Revisions are common in official statistics. According to the 2008 System of National Accounts, revisions are inevitable consequences of the trade-off between the need for both timely and accurate statistics on economic transactions. Policy makers would always prefer official statistics about the economy to be released early. This allows them to rapidly respond emerging concerns. Usually, complete information about the aggregate economic activity of a country may not be available in time for the data to be relevant for policy purposes. Compilers of the National Accounts apply various statistical and econometric techniques in order to produce timely official data on the economy to meet the needs of policy makers. Once the information is complete (or more complete) national statistics agencies worldwide resort to revisions in order to reflect updates in administrative data and more complete response rates from surveys, both of which may not be available during the time when preliminary National Account estimates are scheduled to be release.

Carson at. Al. (2004) noted four reasons for the revision of official statistics, name: to incorporate better source data; to capture routine recalculation; to reflect improvements in methodology, and; to correct for errors. Rinne, H. (1969) said that revisions could be classified either as statistical revisions or conceptual revisions. Statistical revisions results from the availability of new information. The time lag in the production of data required for the estimation of the National Accounts is usually the reason for statistical revisions. In lieu of the actual and final data, National Accounts statisticians and economists often use preliminary data and apply statistical procedures, and econometric methods to come up with estimates that should be as close as possible to the actual or final value. The availability of census data can also be a source of statistical revisions.

As mentioned earlier in the introduction, the preliminary estimate of the GDP growth typically undergoes four rounds of revisions. These revisions fall under the category of statistical revisions. The latest round of conceptual revisions for the National Accounts of the Philippines was undertaken by the NSCB in 2010, as the Philippines shifted its based year to 2000 (from 1985) and incorporated some of the recommendations in the 2008 System of National Accounts Manul (2008 SNA). The size and nature of the revisions of official statistics in the Philippines is a topic that is largely unexamined by both the PSA and independent researchers. We found only two studies analysing the revisions in the National Accounts of the Philippines, that of Tabunda (2012) and Poquiz (2016).

Tabunda (2012) analyzed the revisions of Philippine GDP growth rates and found that structural breaks resulting from the changes in the estimation methodology has had an impact on nature and magnitude of revisions. Smaller revision were noted after 2004. The study noted that revisions do not exhibit a tendency to go upwards. Moreover, GDP revisions do not exhibit a tendency to go upwards or downwards and year-later revisions show evidence of news or clear news signal (Tabunda, 2012).

Poquiz (2016) went on further by examining the revisions growth rates of the industries under the production accounts. The study found that while revisions on GDP growth are relatively small (not exceeding 1.7 percentage points on average), some sectors like Mining and Quarrying and Construction is presented to have large revisions. The study also found evidence of Autocorrelation present in revisions in the growth rates of Gross National Income. Moreover, the study also revealed that variances the revisions of some industries tends to be larger than the variance of the revisions of the total GDP.

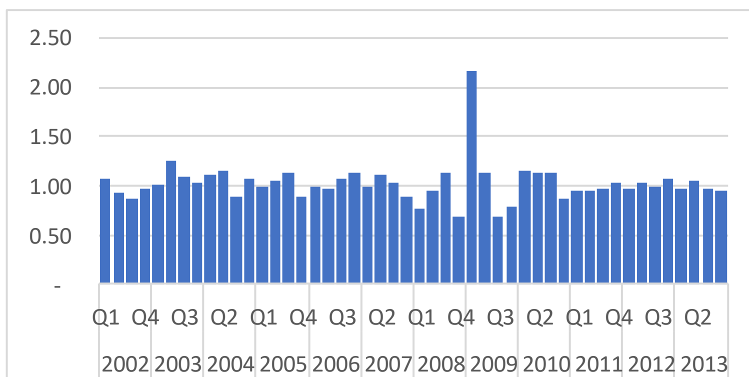

Fig 1. Revisions in GDP growth from 2002 to 2013

In this paper, we analyse the revisions in the GDP growth rates from 2003 to 2013. This study has limited the analysis to statistical revisions and revisions between the final and preliminary growth rates. Revisions in the exercise, is expressed as the absolute value between the preliminary estimates of the GDP growth and the final estimates of GDP growth. Figure1 shows the magnitude of revisions from 2002 to 2013.

As seen from the graph, the absolute magnitude revisions in GDP growth do not appear to exhibit any noticeable pattern. Visual analysis of the absolute level of revisions would point us to recognize that the revisions random in nature.

Table 1. Summary statistics of revisions (2003-2013)

	2002 - 2010	2003 - 2013	2010 - 2013
Max	1.374	1.374	0.512
Min	0.017	0.017	0.040
Ave.	0.017	0.017	0.231
StDev	0.355	0.338	0.123

The data revealed that the largest revision occurred prior to the overall revision in 2010, when GDP growth was revised by 1.4 percentage points for the fourth quarter of 2008. The initial estimate of GDP for the period was 4.5 percent and was eventually revised to 3.1 percent. Trade was the largest contributor to the revision for the said period.

It can also be noted that the average magnitude of revisions was higher after 2010. The average revision for the period spanning from 2010 to 2013 is 0.231 percentage points, compared to 0.017 percentage points from 2002 to 2010, and the overall average of which is roughly at the same magnitude. However, it maybe be too early to draw conclusions from the observed data, considering that there are only three years of data for the period.

4. RESULTS AND DISCUSSIONS

A 95 percent confidence interval and 95 percent credible intervals were generated for using both classical regression and the Bayesian methodology, respectively. The performance of interval generated using both Classical Linear Regression model and the Bayesian methodologies were compared against the performance of the interval generated by the PSA methodology. The results are summarized in Table 2.

Based on the analysis, the intervals generated by the methodology of the PSA failed to capture the final GDP growth rate 18 times or 56.3 percent of the time from 2002 to 2013.

The intervals generated by the classical linear regression, and the regression using Bayesian linear regression (Jefferey's Prior and Inverse Gamma), performed substantially better than the methodology being implemented by the PSA. These methodologies generated intervals which failed to capture the final GDP growth only 3 times from 2003 to 2013 or 9.4 percent of the time.

Table 2. Comparison of interval performance

	Based on a 95% Confidence/Credible Interval				
	PSA Method	Classical Regression	Bayesian Approach		
			Jefferey's Prior	Uniform Prior	Inverse Gamma
No. of Miss	18	3	3	6	3
% Miss	56.3	9.4	9.4	18.8	9.4
Spread (percentage points)	0.66	2.67	2.67	1.49	2.71

It can be noticed that the intervals generated by Classical Linear Regression the Bayesian Approach utilizing the Jeffrey's Non-Informative Prior are strikingly similar. This is likely because the use of non-informative priors allows the information from the data to dominate the modelling process.

The resulting intervals were substantially larger in spread, at 2.67 percentage points, compared to the interval generated by the PSA methodology with a spread of only 0.66 percentage points.

The intervals generated utilizing the Uniform Prior did not perform as well as the other approaches in terms of capturing the final GDP growth, however, it has a relatively shorter spread. As mentioned before, while intervals with large spreads may be effective in capturing the true population characteristic, large-spread intervals may have little use for analytic purposes as it reflects a large degree of uncertainty.

5. CONCLUSION

While the intervals generated by the classical linear regression was able to yield substantially better estimates, the results from the use of the Bayesian method shows a lot of promise. The results from the Bayesian analysis. The specification of prior (particularly for the case of the uniform prior) could set upper and lower bounds for the intervals. This could allow the PSA the flexibility to adjust the interval in the event that they expect large revisions resulting from incompleteness of data. Levels or precision could also be adjusted depending on the expectation of the statistical agency with regard to data revisions.

Further studies should be done on the subject of interval estimation of the national accounts. Even more important, more studies are needed examining revisions in the National Accounts. The strength of Bayesian analysis lies with the use of prior information in the estimation process. More studies on the nature and size of revisions could be useful in the selection of priors for interval estimation of GDP growth rates.

6. REFERENCES

Alston, C. L., Mengersen, K. L., & Pettitt, A. N. (Eds.). (2012). *Case studies in Bayesian statistical modelling and analysis*. John Wiley & Sons.

Carson, C. S., Khawaja, S., & Morrison, T. K. (2004). Revisions policy for official statistics: a matter of governance (Vol. 4). *International Monetary Fund.*

Poquiz, J.L., Moscos S.R.R., and Guiam, E.G. (2016). *Improving the Interval Estimation of the National Accounts of the Philippine.* National Convention on Statistics.

Rinne, H. (1969). ON REVISIONS IN NATIONAL ACCOUNTS ESTIMATES1. *Review of Income and Wealth*, 15(3), 229-245.

Tabunda, A. M. L. (2012). Analysis of Revisions to the Quarterly GDP Growth RateLecture No. 4. *BSP-UP Professorial Chair Lectures.*

Virola, R. and Parcon, G. (1996). *Estimating the Confidence Interval of GDP Grow Rates*. 1996 National Convention on Statistics.

Note: Full paper can be included in the conference proceedings.